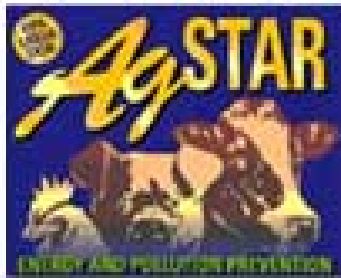


THE IMPLEMENTATION OF ANIMAL BIOMASS TO ENERGY PROJECT AT A LARGE SCALE DAIRY IN JEROME, IDAHO

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GE Jenbacher



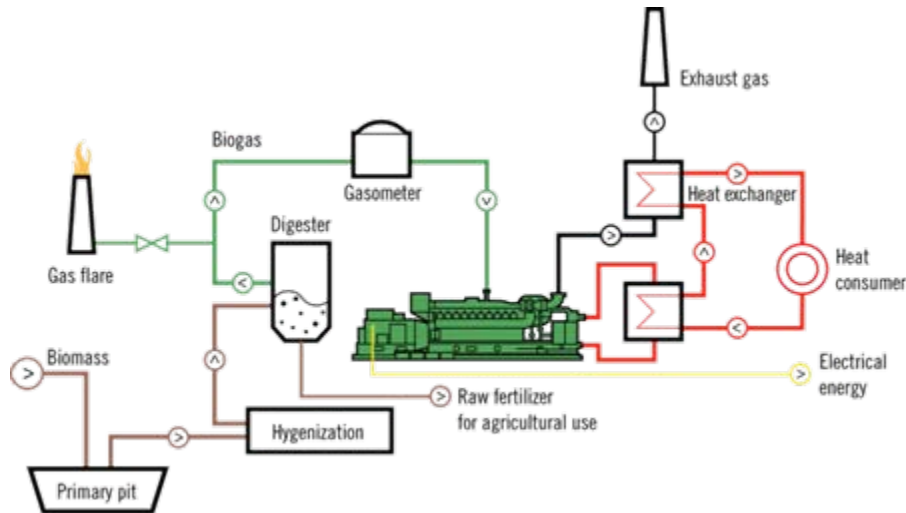
AGSTAR 2009
February 24, 2009

OVERVIEW

- Anaerobic Digestion for Animal Biomass
- Power Generation from Biogas
- GE Energy/Cargill Collaboration at Jerome, Idaho

ANAEROBIC DIGESTION

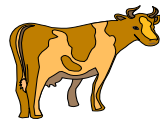
ANAEROBIC DIGESTION OF ANIMAL BIOMASS



- Temperature
 - mesophile (30 - 38°C)
 - thermophile (45 - 55°C)
- Retention time
 - at least 15 days
 - margin: 20 - 50 days
 - common: 25 - 30 days
- Dry matter concentration
 - dry fermentation: 20 - 30%
 - wet fermentation: 10 - 15%

1 Live Stock Unit (LSU) = 500 kg live weight respectively

1 LSU = 0.6 - 1.2 milking cow
approx. 1.3 m³ Biogas/LSU, day
LHV = approx. 6.0 kWh/Nm³



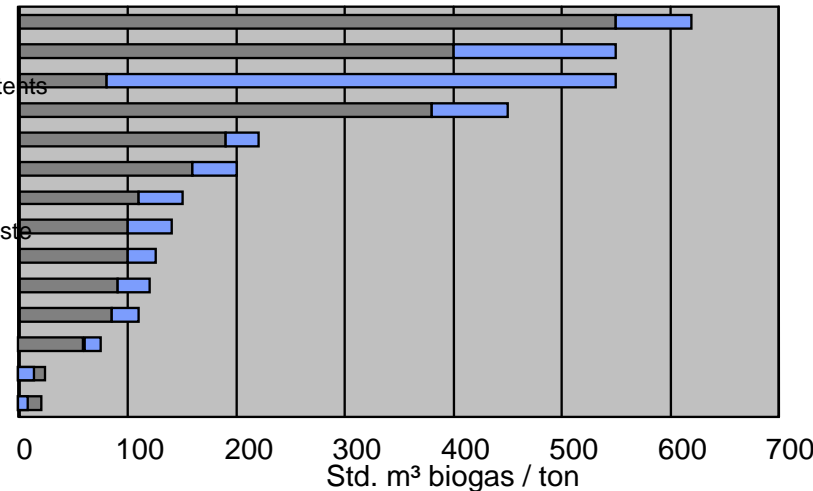
1 LSU = 2 - 6 hogs
approx. 1.5 m³ Biogas/LSU, day
LHV = approx. 6.0 kWh/Nm³



1 LSU = 250 - 320 layers
approx. 2 m³ Biogas/LSU, day
LHV = approx. 6.5 kWh/Nm³



waste wheat
waste bread
grease trap contents
corn-cob-mix
corn silage
grass silage
food waste
municipal biowaste
potatoes
beet
grass cuttings
potato peelings
pig manure
cattle manure



Animal Biomass to Energy Conversion through Anaerobic Digester

Anaerobic digestion is a natural process that converts biodegradable material into 60-70% methane (CH_4) and 30-40% carbon dioxide (CO_2). The primary benefits of the process include odor reduction, production of a renewable energy source (biogas), reduction of greenhouse gas (GHG) emissions, and pathogen-reduced residual solids material. The biogas produced can be converted into electricity by generators or “scrubbed” and condensed for natural gas and LNG applications.

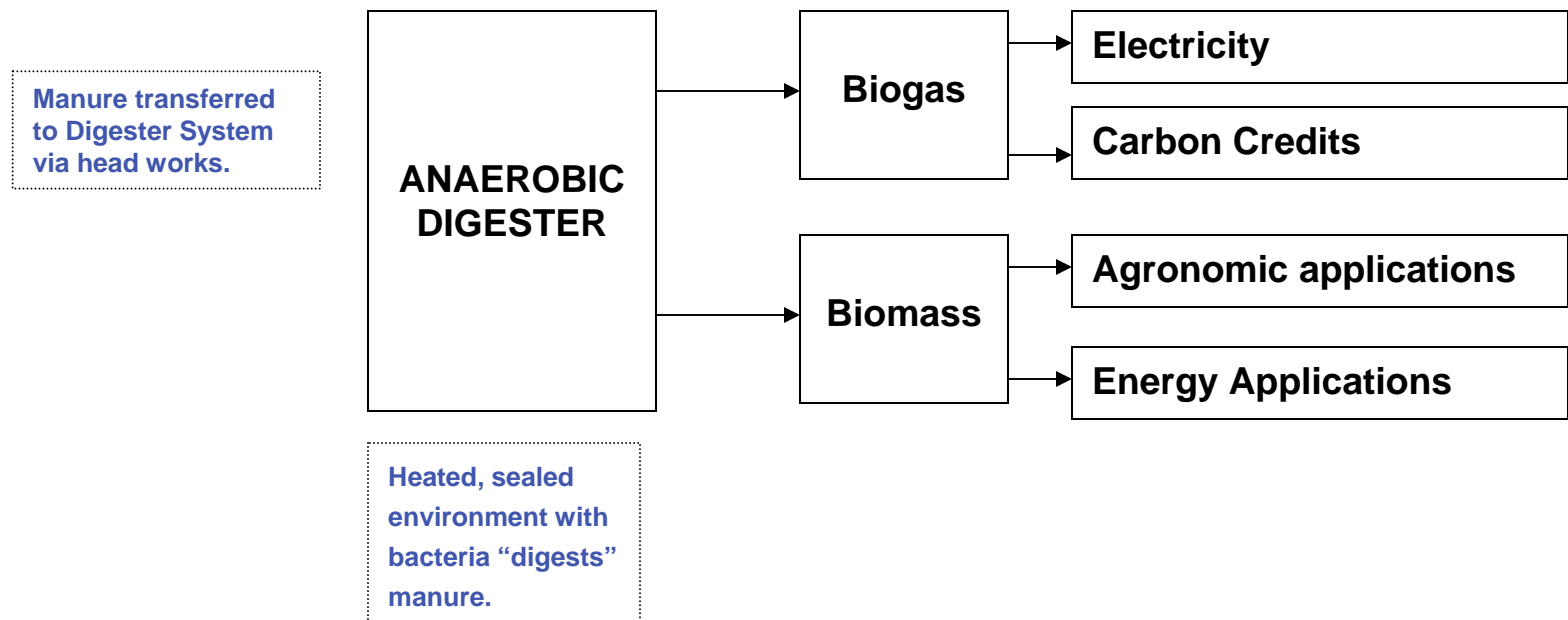
The anaerobic digester’s potential capabilities, combined with the global focus on GHG emission reduction and renewable energy, has created opportunities for scalable leverage due to the following drivers:

1. Increased utility demand for purchasing energy/“green” power
2. U.S. State and Federal mandates and Renewable Portfolio Standards
3. Increasing regulation of animal waste concentration, greenhouse gas and odor management
4. Over 27 million pounds of dairy waste requiring mitigation
5. Over one billion tons of manure produced in the U.S. each year.
6. An estimated 51 to 118 million metrics of carbon dioxide equivalent from livestock manure emissions produced in the U.S. each year
7. 3.928 trillion BTUs of biogas potential from this sector for the U.S. renewable energy market

Animal Biomass to Energy Conversion through Anaerobic Digester

Biogas is a mixture of methane and carbon dioxide naturally created in the process of anaerobic digestion of organic waste. Properly collected and handled, biogas from anaerobic digesters can be used for steam generation in an existing boiler with few and inexpensive modifications. Electricity and natural gas/LNG can also be generated from biogas, the former using dedicated generator sets and the latter with appropriate scrubbing and condensing equipment.

Biomass: As part of the anaerobic digestion process, the biomass can be further processed to improve the efficiency of the agricultural waste flow, therefore fully optimizing the original waste. About one third of the total solids entering the digester can be collected and diverted to multiple applications that include on-farm, agronomic and biomass-to-energy.



Advantages of Anaerobic Digestion

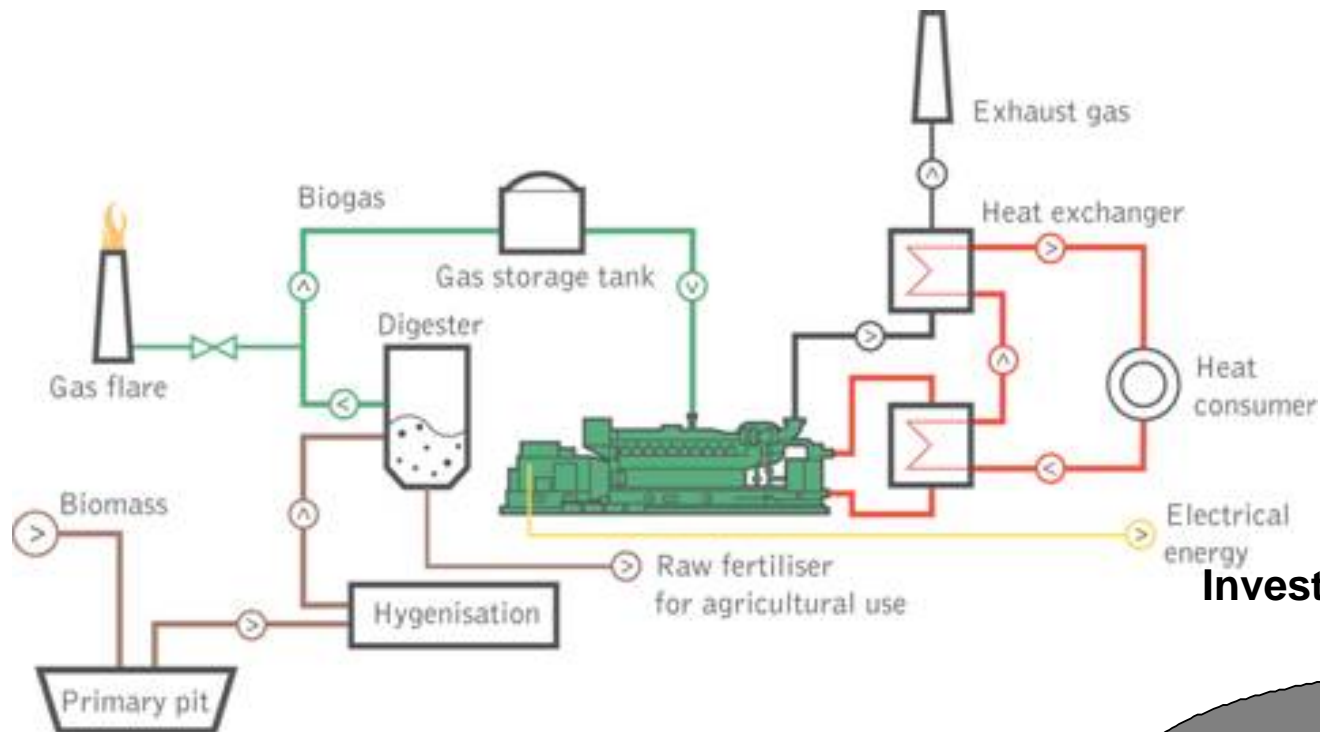
For the Farmer:

- **improvement of manure properties:** odor reduction, elimination of acid components, viscosity decrease, mineralization of organic nitrogen, reduction of pathogenic germs and weed seeds
- **additional** incomings from **heat and power production**
- **waste water treatment** without costly sewer connection

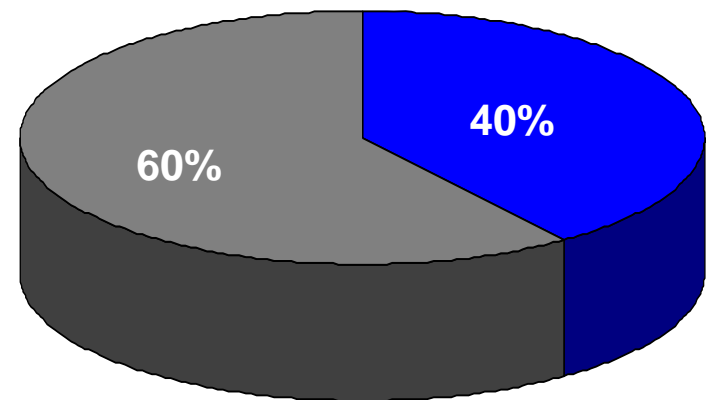
For the Environment:

- **reduction of methane and ammonia emissions** from manure
- **reduction of nitrate wash-out** into groundwater
- **recycling of fertilizer compounds** from organic wastes
- **reduction of carbon dioxide emissions** by substitution of fossil resources

Anaerobic digestion of Biomass



Investment costs:



**Biomass preparation,
digester, Gas holder,...**

**Containerized
Cogeneration plant**

Wet Cow Equivalent

- What is a Wet Cow Equivalent
 - A lactating cow held in a confined flushed stall has the highest quality and quantity manure. This is our ideal Wet Cow Equivalent
 - For planning purpose we scale the animal heard to number of Wet Cow Equivalent
 - Heifer and dry cows are equivalent to $\frac{1}{2}$ WCE for planning purposes
 - Lactating cows held on open lot are equivalent to $\frac{1}{2}$ to $\frac{2}{3}$ WCE because of lower recovery of manure from the flushing of the feeding lanes



Estimation of energy production potential from wet dairy cows (WCE- Wet Cow Equivalent)

- Total Suspended Solids TSS: 7.0 ± 0.5 kg/WCE/day (15.4 ± 1.1 lb/cow/day)
- Volatile Suspended Solids VSS: 5.6 ± 0.2 kg/WCE/day (12.3 ± 0.4 lb/cow/day)
- Flush volume 125 l/WCE/day (33 gal/WCE/day)
- VSS destruction rate: 38 ± 3 %
- CH₄ yield: 0.76 ± 0.1 m³ CH₄/kg (12.2 ± 1.6 ft³ CH₄/lb) of TSS destroyed
- Gas per WCE
 - $5.6 \times 0.38 \times 0.75 = 1.60$ m³ CH₄/WCE/day (**56.50 ft³ CH₄/cow/day**)
- Energy content of methane: 35.85 MJ/m³ (960 BTU/ft³)
- Electrical efficiency 35%
- Energy per cow
 - Fuel $35.85 \times 1.60 = 57.36$ MJ/WCE/day (**54,367 BTU/WCE/day**)
 - Electric $57.36 \times 0.2278 \times 0.35 = 5.55$ kWh/WCE/day
 - $54,367 \times 0.00029 \times 0.35 =$
- Power per cow
 - $5.55/24 = 0.23$ kW/WCE
- Methane in biogas 60% v/v
- Capital cost including generators **\$850-\$1200/WCE** as of June 2008 inclusive of electrical generation. Variability dependent on extent of head works and other site specific requirements

These are **planning figures only** valid for the US operation
Large variability should be expected and should not replace
actual measurements

POWER GENERATION FROM BIOGAS

Energy Projects with Reciprocating Engines

- High Electrical Efficiencies
- High Thermal Outputs
- Low Emissions
- Engine Reliability and Availability
- Maintenance and Parts



Design Considerations

- Gas quantity and quality
- Emissions regulations and permitting
- Utility interconnection
- Space
- Equipment and Project costs
- Operating costs
 - Gas (consumption and treatment)
 - Maintenance
- Revenues
 - Electricity offset or price
 - Carbon Credits
 - Tax credits, VEFs, RECs
- Waste Heat Recovery
 - (Long-term economics)

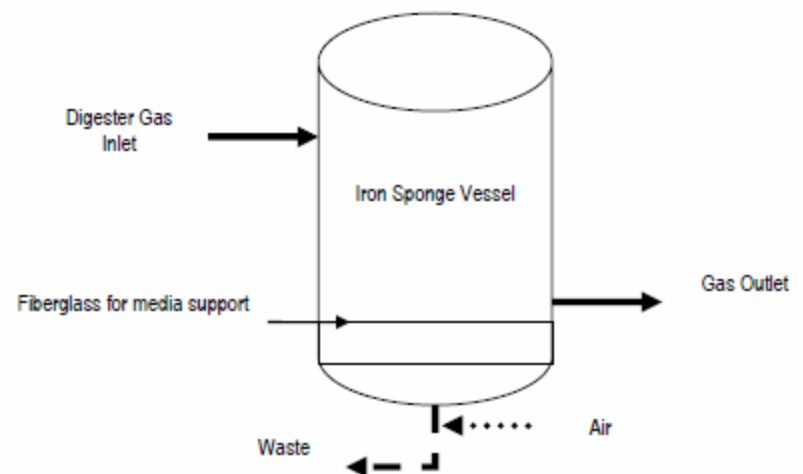


**Determine
Project
Economics**

GAS REQUIREMENTS

Standard biogas requirements to genset:

- Pressure: low > 3psig (except 6-series)
- Temperature: < 104deg preferred
- Moisture: < 80% rel. humidity Contaminant knockout
- Gas analysis for H₂S consideration

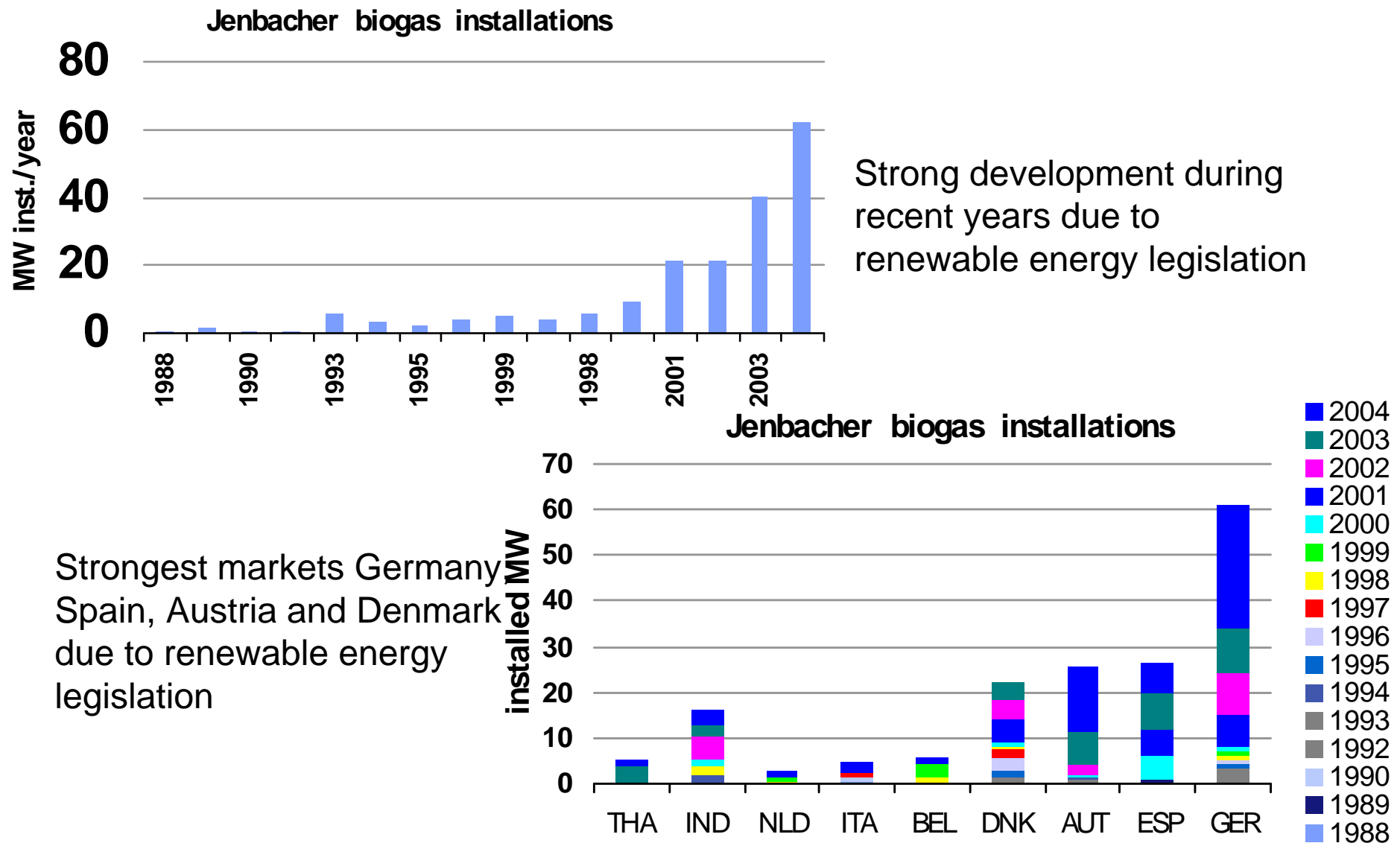


Space Considerations

Loose Genset vs. Packaged Container

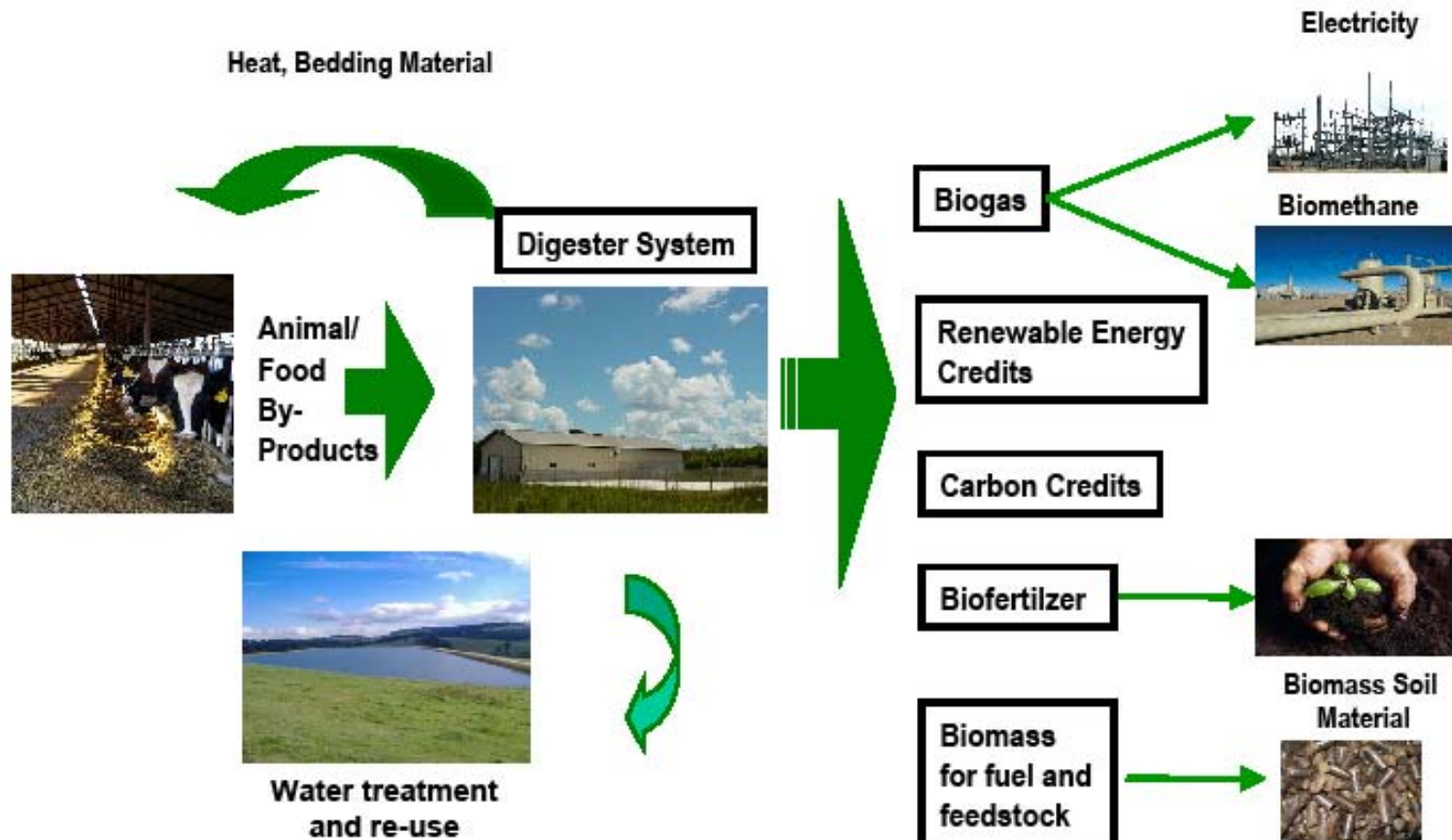
- Loose Genset
 - Building or enclosure required
 - Design and Installation more complex due to subsystem:
 - Cooling System – Radiators, pumps, valves, plumbing
 - Exhaust System – Silencers, wraps, plumbing
 - Lube Oil System – Tanks, pumps, piping
 - Electrical – MCC, switchgear, controls, wiring
 - Ventilation – Fans, louvers, controls
 - Gas Trains – Support, location, plumbing
- Packaged Container
 - Engineered, installed and guaranteed by Factory
 - Plug and Play design:
 - Gas supply in
 - Electrical out (no Utility protection or special gear)
 - Portable

Jenbacher sales in biogas segment



GE ENERGY/CARGILL COLLABORATION FOR PROJECT AT JEROME, IDAHO

Flow Chart of a typical Animal Biomass to Energy Project



DAIRY FARM BASED ANAEROBIC DIGESTER PROJECT AT JEROME, IDAHO



Project specific data (expected):

2 – JMC 416

Plant Output – 2.276 MW

Thermal Output – 8.246 MBTU/hr

Biogas Required

Flowrate = 704 SCFM

LHV = 457 Btu/SCF

Electrical Efficiency = 40.2%

Thermal Efficiency = 42.7%

Emissions (NO_x) < 1.1 g/bhp-hr

QUESTIONS?